Technical Support Document
APPENDIX F

Revisions to the Yuma PM_{10} Emissions Inventory (June 2006)

The PM_{10} emissions inventory for Yuma, assembled by E. H. Pechan, released as "1999 and 2016 Emission Estimates for the Yuma, Arizona PM_{10} Nonattainment Area Maintenance Plan", June 2003, and presented as Appendix A of this Technical Support Document, has been revised as described below. Certain categories were recalculated, a few new categories were added, and the emission totals are now presented for both the larger study area and the nonattainment area.

Original 1999 Emissions Inventory

The following are the contractor's emission estimates as given in the above report (Table F-1). Estimates for 2005 were interpolated from the 1999 and 2016 totals.

Table F-1. Yuma Study Area PM_{10} Emissions – Contractor Inventory

Source Category	Annual tons of PM_{10}		
	1999	**2005**	**2016**
Agricultural and Prescribed Burning	40.7	38.4	34.1
Agricultural Tilling	3,572	3,572	3,572
Agricultural Cultivation and Harvesting	15.7	15.7	15.7
Windblown Dust	130,331	129,172	127,046
Unpaved Roads - Re-entrained Dust	10,183	8,543	5,537
Paved Roads	3,419	4,273	5,839
Road Construction	6,761	8,152	10,702
General Building Construction	53.8	65.8	87.7
Aircraft	15.5	15.8	16.4
Unpaved Airstrips	1.0	1.0	1.1
Stationary Sources	77	92	119
Railroad Locomotives	17	16	15
Total	154,487	153,957	152,985

Unpaved Roads

The original work did not account for the constant that needs to be subtracted in the primary AP-42 emission factor equation for unpaved roads.

$E = [k[s/12]^{0.97} x[S/30]^{0.46}]/[M/0.5]^{0.23}] - C$, where

E = Particulate emission factor in pounds per mile

k = Particle size multiplier = 1.8

s = road surface silt loading

S = speed in miles per hour

M = surface moisture content in percent

C = Emission factor for 1980's vehicle fleet exhaust, break wear, and tire wear

The constant "C" has the value of 0.2119 grams per mile, while typical values of moisture content, speed, and silt content for southern Arizona yield an unpaved road emission factor of 250 grams per mile. Correcting for this factor can be done by multiplying an emission total by 0.999152 (Table F-2).

Table F-2. Original and Revised Unpaved Road Emissions

Source Category	Annual Tons of PM_{10}		
	1999	**2005**	**2016**
Original Unpaved Roads	10,183	8,543	5,537
Revised Unpaved Roads	10,174	8,536	5,532

Paved Roads

The contractor used MOBILE6.1 and the AP-42 equation for reentrained dust to estimate these emissions. The more recent version MOBILE6.2 has the same emission factors for exhaust, brake, and tire wear as the earlier version. The contractor did subtract the constant C, 0.2119 grams per mile, as laid out in current EPA guidance. These emission factors used by the contractor are current, so the emissions need no revision.

Windblown Dust – Vacant Agricultural Fields

These emissions have been reduced by 90%. The contractor had estimated that from 10 to 40% of agricultural fields were vacant, depending on the season. In talks with Yuma area farmers and conservation agents, however, it was learned that the typical Yuma farm field is "vacant" – unirrigated, unplanted, and susceptible to wind erosion – only ten days per year. This leads to a 90% reduction in windblown emissions from these fields. The original inventory figures for windblown dust are given in Table F-3.

Table F-3. Windblown Emissions – Contractor Inventory

Windblown Dust Category	1,999	2,005	2,016
Vacant Ag Fields	65,835	65,607	65,188
Miscellaneous Disturbed Area	33,996	33,996	33,996
Unpaved Ag Roads	22,160	22,083	21,942
Urban Disturbed Area	5,442	4,588	3,021
Alluvial Plains	2,517	2,517	2,517
Native Desert	282	317	382
Total	130,232	129,108	127,046

The revised figures, in which the "Vacant Ag Fields" windblown emissions have been lowered by 90%, are given in Table F-4.

Table F-4. Windblown Emissions – With Revised Vacant Ag Fields

Windblown Dust Category	1999	2005	2016
Vacant Ag Fields	**6,584**	**6,561**	**6,519**
Miscellaneous Disturbed Area	33,996	33,996	33,996
Unpaved Ag Roads	22,160	22,083	21,942
Urban Disturbed Area	5,442	4,588	3,021
Alluvial Plains	2,517	2,517	2,517
Native Desert	282	317	382
Total	**70,981**	**70,062**	**68,377**

Since the contributing sources of the 2002 Natural Events Action Plan (NEAP) were based on the original inventory, there is some question whether an inventory change of this magnitude would change the importance of sources for the Best Available Control Measures analysis of the NEAP. The answer to this question, with the exception of the vacant fields category, is no, as explained in the following section.

Yuma PM_{10} Maintenance Plan: Consistency with the Natural Events Action Plan's Contributing Sources in Light of the Reduction of Windblown Dust Emissions from Vacant Agricultural Land

Introduction

The Yuma PM_{10} monitor recorded an exceedance of 170 ug/m3 for a 24-hour average on August 18, 2002. The day qualified as an exceptional event and a Natural Events Action Plan (NEAP) was carried out. As part of this plan, Best Available Control Measures (BACM) were considered for all the contributing sources. These sources were identified through emissions and air quality modeling. One of the major contributors, windblown dust from vacant agricultural fields, was later found to be a large over estimate. The contractor building the emissions inventory had assumed that agricultural fields would be "vacant" or "fallow" in the following amounts: 35% in the fall, 40% in winter, 10% in spring and summer. In meetings with Yuma farmers and agricultural agents in 2005, however, Assessment Staff learned that these were large over estimates. Instead of these high percentages, the Yuma farming community stated that on average, each field was fallow for ten days a year. Calculations then showed that on an annual basis, the emissions from vacant agricultural fields needed to be reduced by 90%. This paper reexamines the contributing sources identified in the NEAP in light of this inventory correction.

Results

In the following discussion, the "contributions" are those from a particular kind of emissions source to the model-predicted concentration averaged 24 hours at the Yuma Juvenile Center PM_{10} monitor. The net modeled concentration can be broken down into its component parts, each part a different emission source. Correcting the contribution from windblown emissions from vacant agricultural fields can be done in at least two ways. Its contribution can be reduced 90%, and the other categories increase proportionately such that the new modeled total concentration equals the old one. The other way is to simply leave the contributions from the other sources as they were, changing only the vacant agricultural fields contribution. Results from both ways are shown below: they produce similar distributions of contributions (Tables F-5 and F-6).

Table F-5. Contributing Sources to Yuma PM_{10} on August 18, 2002, Micrograms per Cubic Meter			
SOURCE	**ORIGINAL**	**REVISION 1**	**REVISION 2**
PAVED ROADS	23.6	28.3	23.6
WIND – AG. FIELDS	15.2	1.5	1.5
WIND - MISC. DIST AREAS	13.7	16.4	13.7
WIND - UNPAVED AG. ROADS	12.9	15.4	12.9
WIND - URBAN DIST AREAS	9.0	10.8	9.0
CONSTRUCTION	7.9	9.4	7.9
UNPAVED ROADS	1.4	1.6	1.4
AIRCRAFT	0.5	0.6	0.5
OTHERS	0.3	0.4	0.3
WIND - ALLUVIAL	0.1	0.1	0.1
TOTAL	84.5	84.5	70.9

Revision 1: 90% reduction of vacant ag fields; other categories increased.

Revision 2: 90% reduction of vacant ag fields; other categories unchanged

Table F-6. Contributing Sources to Yuma PM_{10} on August 18, 2002, Percentages			
SOURCE	**ORIGINAL**	**REVISION 1**	**REVISION 2**
PAVED ROADS	27.9	33.4	33.3
WIND - AG. FIELDS	17.9	1.8	2.1
WIND - MISC. DIST AREAS	16.2	19.4	19.3
WIND - UNPAVED AG. ROADS	15.3	18.3	18.2
WIND - URBAN DIST AREAS	10.6	12.7	12.7
CONSTRUCTION	9.3	11.2	11.1
UNPAVED ROADS	1.6	1.9	1.9
AIRCRAFT	0.6	0.7	0.7
OTHERS	0.4	0.5	0.5
WIND - ALLUVIAL	0.1	0.1	0.1

The revisions make little difference in the percentage contributions from this set of emission sources, with the exception, of course, of vacant fields. The important contributing sources of the NEAP can now be compared with those from this inventory revision (Table F-7).

Table F-7. Contributing Sources to Yuma PM_{10} from the NEAP and with the Revision to Windblown Emissions from Vacant Agricultural Fields			
Sources from the NEAP	**%**	**Sources with the Revision**	**%**
PAVED ROADS	27.9	PAVED ROADS	33.4
WIND – AG. FIELDS	17.9	WIND - MISC. DIST AREAS	19.4
WIND - MISC. DIST AREAS	16.2	WIND - UNPAVED AG. ROADS	18.3
WIND - UNPAVED AG. ROADS	15.3	WIND - URBAN DIST AREAS	12.7
WIND - URBAN DIST AREAS	10.6	CONSTRUCTION	11.2
CONSTRUCTION	9.3	UNPAVED ROADS	1.9
UNPAVED ROADS	1.6	WIND - AG. FIELDS	1.8
AIRCRAFT	0.6	AIRCRAFT	0.7
OTHERS	0.4	OTHERS	0.5
WIND - ALLUVIAL	0.1	WIND - ALLUVIAL	0.1

The top six from the NEAP are paved roads, windblown ag fields, windblown miscellaneous disturbed area, windblown unpaved ag roads, windblown urban disturbed areas, and construction. In the revision, the top five are all of those from the NEAP less the windblown ag fields. With this revision the relative contribution from unpaved agricultural roads increases, while the relative contribution from agricultural fields decreases. The revision does not alter the order of the other contributing sources.

General Building Construction

These emissions were calculated without corrections for moisture and silt content. For moisture, the factor in the equation is (24/PE), where the PE value of 6 should have been used. This increases the emissions by 4.0. The silt adjustment factor is (s/9), where s is the silt content in percentage. The silt value of 40% should have been used, increasing the emissions by (40/9) = 4.44. With these two adjustments, the emissions are increased by about a factor of 16, as shown in Table F-8.

Table F-8. Original and Revised General Building Construction Emissions			
Source Category	**Annual tons of PM_{10}**		
	1999	2005	2016
General Building Construction-original	53.8	65.8	87.7
General Building Construction-revised	955.5	1,168.0	1,557.6

Road Construction

Road construction emissions did factor in both the moisture and silt content, but appeared to have applied a monthly emission factor to annual construction totals. These emissions have been recalculated, as shown below in the two tables. The original estimates were too high by factors of three to 20. The following equation was used.

$E_{cor} = Ef * (24/Mf) * (s/9)$, where

E_{cor} = corrected emissions

E_f = emission factor of 0.42 tons/acre/month

M_f = moisture factor, (PE), for Yuma, 6

s = silt content in percent, for Yuma, 40%

Table F-9. Revised Road Construction Emissions -- 1999

	Revised Calculations for 1999						From Inventory	
Agency	**Miles/Yr**	**Acres/Mi**	**Acres/Yr**	**Acres/Mon**	**Tons/Mon**	**Tons/Year**	**Tons/Yr**	**Calc/Inv**
Somerton	2.52	9.8	24.7	2.1	15.37	**184**	1383	0.13
City of Yuma	7.2	9.8	70.6	5.9	43.90	**527**	3951	0.13
Yuma County	1.9	9.8	18.6	1.6	11.59	**139**	384	0.36
ADOT	0.7	9.8	6.9	0.6	4.27	**51**	1043	0.05
Total	12.32	9.8	120.7	10.1	75.12	**901**	6761	0.13

Table F-10. Revised Road Construction Emissions -- 2016

	Revised Calculations for 2016						From Inventory	
Agency	**Miles/Yr**	**Acres/Mi**	**Acres/Yr**	**Acres/Mon**	**Tons/Mon**	**Tons/Year**	**Tons/Yr**	**Calc/Inv**
Somerton	0	9.8	0.0	0.0	0.00	**0**	0	NA
City of Yuma	11.1	9.8	108.8	9.1	67.69	**812**	6092	0.13
Yuma County	3.6	9.8	35.3	2.9	21.95	**263**	2634	0.10
ADOT	4.8	9.8	47.0	3.9	29.27	**351**	1976	0.18
Total	19.5	9.8	191.1	15.9	118.91	**1427**	10702	0.13

ATV Emissions

Emissions from all-terrain vehicles (ATVs) do not appear in the PM_{10} emissions inventory prepared by Pechan. As one of the chief forms of recreation around Yuma is driving these vehicles over the desert and dunes, this omission was unfortunate but not terribly important. Here's why.

Generally, off-road vehicles are not used in paved, urbanized areas such as the majority of the land within the boundaries of the Yuma PM_{10} air quality planning area. Instead, these vehicles are used in outlying, unpaved areas such as the Ehrenburg Bowl Off-Highway Vehicle Recreation Area near Blythe, Arizona, in La Paz County and the Imperial Sand Dunes Recreation Area approximately 20 miles west of Yuma in California. Certainly some ATV activity takes place in the more remote areas of the Yuma planning area, especially along the Yuma Mesa along the slopes of the Gila Mountains.

For this discussion only, we assume that all of the ATV activity takes place within the planning area. This assumption leads to a large over estimate of the PM_{10} emissions from this source. Even with this erroneous excess, the ATV emissions are still a small part of the larger emissions picture. For example, calculations from a bottoms-up approach suggest that the ATV emissions – both exhaust and tailpipe – are less than one percent of the anthropogenic total. This low percentage contribution is confirmed by the National Emissions Inventory. Consequently, their omission from the inventory has little consequence. Their omission from the air quality modeling has even less, even for the simulations of the 24-hour average PM_{10} concentrations.

The following tables present the statistics.

ADEQ concludes that emissions from this small percentage of mobile sources in the Yuma PM_{10} planning area would not contribute to nonattainment or interfere with attainment of the PM_{10} NAAQS in the Yuma air quality planning area in the next 10 years.

Table F-11. ATV Activity Data and Emissions			
Activity data for Yuma area ATVs			
Item	**Statistic**	**E-Factor**	**Emissions**
		g/mile	tons/yr
Atvs In Yuma County	8400		
Days Per Year Of Use	40		
Mileage To And From Area	80		
Mileage Of Offroad Use Per Day	10		
Onroad Mileage Per Year	26880000	0.06	1.61
Offroad Mileage Per Year	3360000	0.6	2.02

Roadway Emissions

	1999	2016
Unpaved Roads	10,183	5537
Paved Roads	3,419	5839
Anthropogenic inventory total	24,157	25,939

ATV Contributions in %	1999	2016
ATVs % of unpaved roads	0.020	0.036
ATVs % of paved roads	0.047	0.028
ATVs % of anthropogenic inventory	0.015	0.014

National Emissions Inventory Yuma PM_{10} Emissions	**(Tons/Year)**
ATV 2-stroke exhaust	0.03
ATV 4-stroke exhaust	0.32
Exhaust total	0.35
Fugitives	2.02
Total	2.37

Pechen Inventory Totals	1999	2016
Anthropogenic inventory total	24,157	25,939
ATVs % of anthropogenic inventory	0.010	0.009

Lawn and Garden Emissions

Emissions from lawn and garden equipment were estimated by using the fraction of the Maricopa County PM_{10} emissions that are lawn and garden, and applying the fraction to the Yuma inventory. The Maricopa County figures come from "Cap-and-Trade Oversight Committee – Final Report", January 16, 2004.

Table F-12. Lawn and Garden Emissions			
	1999	**2005**	**2016**
MC lawn/garden emissions (tons/yr)	127	155.2	207
MC total emissions	83,375		
fraction of MC that is lawn/garden	0.0015		
Yuma PM_{10} emissions total	90,319		
Yuma lawn and garden (tons/yr)	**145**	167	207

Light Commercial Vehicles In the Offroad Category

Light commercial vehicles in the nonroad sector are small nonroad trucks, forklifts, small tractors and loaders used in construction; forklifts and small industrial riding sweepers, and various kinds of small farm vehicles such as riding mowers. To calculate these emissions for Yuma, two inventories were consulted: 2004 California statewide inventory, and the Maricopa County cap and trade inventory. Precise accounting for these vehicles had not been done in the nonroad inventories: Emissions from the various horsepower categories in the California inventory were assumed to be ten percent from these vehicles. The fraction of nonroad engines from these light commercial vehicles in the California inventory was applied to the nonroad total in the Maricopa inventory. The Maricopa fraction of light commercial vehicles was then applied to the Yuma PM_{10} inventory.

Table F-13. Calculations for Light Commercial Vehicle Emissions			
California Statewide Inventory	**Tons/Day**	**Fraction Vehicles**	**Vehicles Tons/day**
Offroad Engine Total	16.01		
2-Srk < 25 Hp	0.07	0.1	0.007
4-Strk < 25 Hp	0.41	0.1	0.041
4-Strk > 25 Hp	0.46	0.1	0.046
Sum Light Commercial	0.94		0.094
Fraction Of Total Nonroad	0.006		
Maricopa PM_{10} Inventory (Cap Trade)			
Total	83375		
Commercial Equipment	141	0.1	14.1
Fraction Com	0.0002		
Total Offroad	2608		
Lt Comm Veh	15.31		
Fraction	0.0002		
Yuma Total	90319		
Yuma light commercial vehicles	16.58		

Yuma PM_{10} Inventory – Revised

Table F-14 is the revised inventory, with those categories in bold being the ones that were revised or added. These figures are for the entire Yuma study area.

Table F-14. Yuma Study Area PM_{10} Emissions -- Revised			
Source Category	**Annual tons of PM_{10}**		
	1999	2005	2016
Windblown Dust	**70,981**	**70,062**	**68,377**
Unpaved Roads	**10,174**	**8,536**	**5,532**
Agricultural Tilling	3,572	3,572	3,572
Paved Roads	3,419	4,273	5,839
General Building Construction	**955**	**1,168**	**1,558**
Road Construction	**901**	**1,087**	**1,427**
Lawn & garden	**129**	**157**	**207**
Stationary Sources	77	92	119
Agricultural and Prescribed Burning	41	38	34
Railroad Locomotives	17	16	15
Agricultural Cultivation and Harvesting	16	16	16
Light Commercial Vehicles	**16**	**16**	**16**
Aircraft	16	16	16
ATVs	**3.6**	**4.4**	**5.9**
Unpaved Airstrips	1	1	1
Total	**90,319**	**89,054**	**86,735**

Note: bold figures are revisions to the original inventory of Table F-1

Nonattainment Area Emissions

Emission density plots by source category were examined to estimate the fraction of emissions occurring in the nonattainment area (Table F-15). These fractions were applied to the emissions from the entire study area to estimate the nonattainment area emissions.

Table F-15. Percentage of Emissions of the Entire Study Area Which Come From the Nonattainment Area, by Source Category	
Source Category	**Percent in Nonattainment Area**
Windblown Dust	97
Unpaved Roads - Re-entrained Dust	95
Agricultural Tilling	90
Paved Roads	95
General Building Construction	99
Road Construction	99
Lawn & Garden	99
Stationary Sources	99
Agricultural and Prescribed Burning	98
Railroad Locomotives	60
Agricultural Cultivation and Harvesting	90
Aircraft	99
ATVs	99
Unpaved Airstrips	99

Table F-16. Yuma PM_{10} Emissions in the Nonattainment Area – Revised			
Source Category	**Annual Tons of PM_{10}**		
	1999	2005	2016
Windblown Dust	**68,496**	**67,609**	**65,984**
Unpaved Roads	**9,666**	**8,109**	**5,256**
Agricultural Tilling	3,215	3,215	3,215
Paved Roads	3,248	4,059	5,547
General Building Construction	**946**	**1,156**	**1,542**
Road Construction	**892**	**1,076**	**1,413**
Lawn & garden	**128**	**155**	**205**
Stationary Sources	76	91	118
Agricultural and Prescribed Burning	40	38	33
Railroad Locomotives	10	10	9
Agricultural Cultivation and Harvesting	14	14	14
Light commercial vehicles	**16**	**16**	**16**
Aircraft	15	16	16
ATVs	**4**	**4**	**6**
Unpaved Airstrips	1	1	1
Total	**86,768**	**85,570**	**83,374**

Bold figures are revisions to the inventory of Table F-1; all figures reflect emissions only from the nonattainment area.